(11) AU-A 41551/78

(12) PATENT SPECIFICATION
ABSTRACT
(19) AU

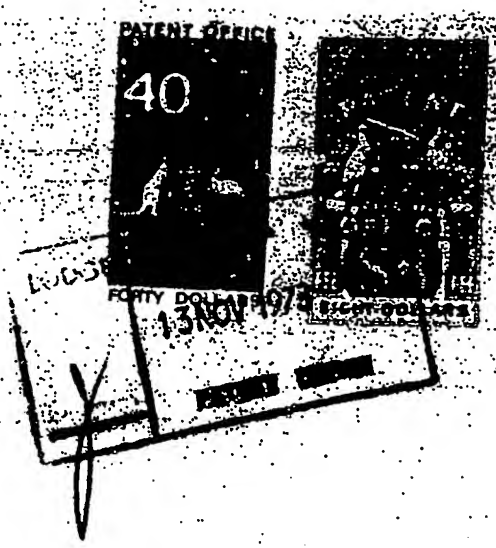
(21) 41551/78 (22) 23.11.77 (23) 13.11.78 (24) 23.11.77
(43) 31.5.79
(51) F24C 15/32

(54) FORCED AIR OVEN

(71) EMAIL LTD.

(57) CLAIM

1. A forced air oven comprising an oven chamber, an air circulating fan mounted within said chamber on a drive shaft extending through one wall of the chamber, heating means mounted within the air stream generated by said fan, a baffle plate mounted in front of the fan in paralleled spaced relation with said one wall, a centrally disposed aperture in said baffle plate to enable air from the chamber to be drawn through the baffle plate by the fan into the region defined by said paralleled spaced relation, a plurality of left-hand and right-hand vanes located on the fan side of the baffle plate in the vicinity of both the top and bottom edges thereof, said plurality of vanes extending across said region in proximity to said one wall and extending beyond both of said top and bottom edges in proximity to the top and bottom walls of said chamber respectively, said left-hand vanes being fewer in number than said right-hand vanes, said left-hand and right-hand vanes subtending acute angles to the vertical such that said air stream substantially exhibits an air curtain flow pattern in said chamber.



ORIGINAL

Applicant: Email Limited

Number: PD 2527/77

Filing Date: 23rd November, 1977

41551/78

FORM 10

REGULATION 13(2)

COMMONWEALTH OF AUSTRALIA

Patents Act 1952-1976

COMPLETE SPECIFICATION FOR THE INVENTION ENTITLED:

"FORCED AIR OVEN"

The following statement is a full description of this invention including the best method of performing it known to us:

This invention relates to cooking ovens and in particular relates to forced air cooking ovens wherein heated air is fan circulated or convected within the oven chamber. The invention finds special application in electric domestic and commercial ovens but is not so limited in its scope.

In a normal domestic or commercial oven, heating means is located on or close to the oven floor and the air heated thereby circulates within the oven chamber under the influence of thermal convection. Heated air is thereby carried to and passes over and around the foodstuff to be baked. As is well known this process of baking is slow and, due to the lack of isothermality, cooking rates vary from one part of the chamber to another. It is therefore very important to void steep thermal gradients within the oven throughout the baking periods to ensure that a uniformly baked product results.

In forced air ovens the oven chamber air is locally heated either by an electric element within the chamber, or by a combustible fuel in a combustion chamber and the heat generated therein is exchanged with the oven chamber air. In both cases the heated air is then force-circulated in some predetermined flow pattern to provide the heating medium for the foodstuff. It is, however, an essential aim of all forced air ovens to provide uniform heating throughout the oven chamber and, to achieve this condition, careful control of the temperature of the circulating medium is required along with similar control over the flow current density and flow patterns of that medium.

The known advantages accruing from the use of forced air ovens include:-

(1) Less baking time is required;

(2) Fuel or energy savings due to (1) and to the

lower operating temperatures permissible;

(3) Reduced thermal gradients within the oven chamber;

(4) More uniformly baked foodstuffs as a result of (3); and

(5) More foodstuffs can be accommodated within the oven for the same baking run.

The ideal goal for all cooking ovens therefore is to approximate isothermal equilibrium throughout the chamber. Experiments have shown that the temperature difference between the hottest and coolest sites in the oven can be as high as 30-40 centigrade degrees at equilibrium and at a baking temperature, say, in the range 150-200°C. While this variation may be tolerable for certain foodstuffs, such as a roast, it is clearly unsatisfactory for other types such as a batch of scones which will show variations in the amount of rise and the degree of browning exhibited.

Whilst it is a relatively simple matter to control the temperature within an oven and to control the flow current density of the circulating medium by controlling, inter alia, the rotational speed and design of the fan's impellor, it is not a simple matter to control the third criterion of control mentioned above.

There are two basic approaches to the control of air flow patterns, known generally as cyclonic turbulence and air curtain respectively. A teaching on the former approach to forced-air ovens is to be found in Australian Patent No.486,780. A teaching on the latter approach may conveniently be obtained from printed British Patent No. 1,417,199, which patent also provides an exposition on the lower temperatures at which baking may proceed in forced-air ovens; this property of the ovens was mentioned in (2) above. Although the dichotomy in the nomenclature of air

flow patterns is a convenient approach in practice, it is somewhat academic since each one is, to varying degrees, a hybrid of the other. That is, the air curtain has certain turbulent properties intrinsically associated with it due, inter alia, to the configuration of the oven chamber, and the cyclonic turbulence exhibits, at least partially throughout, properties common to the air curtain.

In terms of hardware in the present state of the art, both of the aforementioned approaches rely upon a battle plate interprosed between the fan or blower and the oven chamber and it is the design and location of the baffle that dictates the type and nature of the air flow pattern. It is to such a baffle and its location in an oven that this invention primarily directs itself.

According to the invention there is provided a forced air oven comprising an oven chamber, an air circulating fan mounted within said chamber on a drive shaft extending through one wall of the chamber, heating means mounted within the air stream generated by said fan, a baffle plate mounted in front of the fan in paralleled spaced relation with said one wall, a centrally disposed aperture in said baffle plate to enable air from the chamber to be drawn through the baffle plate by the fan into the region defined by said paralleled spaced relation, a plurality of left-hand and right-hand vanes located on the fan side of the baffle plate in the vicinity of both the top and bottom edges thereof, said plurality of vanes extending across said region in proximity to said one wall and extending beyond both of said top and bottom edges in proximity to the top and bottom walls of said chamber respectively said left-hand vanes being fewer in number than said right-hand vanes, said left and right-hand vanes sub-tending acute angles to the vertical such that said air stream substantially exhibits an air curtain flow pattern in said chamber.

The invention will now be described in a preferred embodiment with reference to the accompanying drawings in which:-

Fig. 1 is a schematic representation in partial vertical section of a forced-air oven having some features and integers of the prior art in common with the preferred embodiment of the invention; and

Fig. 2 is a schematic view of the baffle plate of Fig. 1 embodying novel aspects of the invention.

In Fig. 1 there is shown an oven 1 generally comprising an outer metal cabinet 2 and an inner metal liner are thermally insulated from each other by suitable insulating medium 4 in known fashion. The heating element for the oven is provided by the helical element 5 which is supported on the rear wall 7 of the oven by a plurality of brackets 6. Preferably there would be three such brackets 6 in the embodiment of the invention described herein.

The helical axis of the element 5 passes at right angles through the geometrical centre 7 of the rear wall, although some slightly eccentric position may be preferred in special applications.

Passing through the centre of the rear wall, and therefore co-linear with the helical axis, is the drive shaft 8 of an electric motor 9 which is supported on the outside of the rear wall by suitable mounting means such as shown at 10 in the drawing. The motor 9 may be cooled by the addition of an axial fan 11 mounted on the shaft 8 or, if an external rotor motor is used, by an axial fan mounted directly on the rotor laminations, to enable cooling air to be blown around the motor housing.

On the oven end of shaft 8 is located a radial or centrifugal fan or impellow shown schematically at 12 in Fig. 1. The circumferential surface of fan 12 is positioned in close circular juxtaposition with element 5 and, when

spinning, forces air over and around the element. Directly in front of the fan 12, that is on the oven chamber side of the fan, is a baffle plate 13 which is also supported by the element-supporting brackets 6. The baffle plate is described in more detail below with reference to Fig. 2 but it suffices to say, at this point in the description, that the section of the baffle immediately covering the fan 12 is comprised of a circular aperture covered by a grid 14 to allow an even flow of air to be drawn through the baffle by the fan. The grid 14 is so positioned to prevent any solid object coming in contact with the fan blades during operation thereof.

The thermal dynamics of the oven are basically as follows: When the fan 12 is energised, air from the centre of the oven chamber is drawn in through the grid 14 and blown radially outwards, over and around the hot element 5, whereby the air stream thus generated gains thermal energy from the element. The heated air flows around edges 15 and 16 of baffle 13 to form respective air curtain streams B and C. Air curtains B and C generally converge on each other in the front half of the oven to form a returning air curtain stream A which completes the fluidynamic circuit by converging on grid 14 from where the heated air is reheated by the element, as described above.

It will be appreciated that, in an air circulating oven system, it is very important to avoid such common phenomena as localised vortices and aerodynamically quasi-static centres within the oven chamber since these phenomena give rise to relatively high density isotherms. The result is uneven baking due to temperature variations within the chamber. The overall temperature limit is controlled in the usual fashion by a thermostat and the aforementioned flow current density is controlled by the spaced relation between the baffle 13 and the rear wall of the oven in co-operation

with the design of the fan blades and their rotational velocity. These two criteria have few degrees of freedom with which one is able to influence the thermal-baking characteristics of the oven. The third criterion, namely the circulation flow pattern, is the most critical feature of a forced-air oven and is mainly influenced by the design of the baffle plate 13.

The baffle plate 13 is shown in front elevation view in more detail in Fig. 2 and embodies novel features of the invention. The representation of the baffle is as viewed in situ in the oven chamber looking from the front of the oven with its door open. That is, from this view, the fan 12 and heating element 5 are behind the baffle plate and it is assumed that the rotational direction of the fan 12 is clock-wise as viewed from this direction. References to the left- and right-hand sides of the baffle therefore have their normal meaning with respect to clockwise rotation of the fan 12 however it should be clearly understood that, should the fan 12 rotate in the anti-clockwise direction, then references to the left- and right-hand side of the baffle should be construed to have the opposite meaning. That is, if the fan rotates in the anti-clockwise direction, the right-hand side of the baffle now becomes the left-hand side, and vice-versa, for the purposes of this description.

In Fig. 2, the baffle plate 13 is supported on the rear wall of the oven by means of brackets 6 which maintain the baffle in spaced relation thereto and in close proximity to the fan. The brackets 6 are also shown schematically to support the heating element 5 by means of further brackets 17. The baffle 13 as illustrated occupies the full width of the oven chamber and may be secured to the side walls 3 thereof via its upturned edges 18 by any known means, such as screws. Along the top of the baffle and

affixed to the rear side thereof are a series of damper plates or vanes 19 which serve to collect and evenly distribute the fan-generated air currents in the upper half of the baffle-ear wall space.

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The air current velocity vectors are distributed with both radial and tangential components of which the latter are the more significant. One the left-hand side, the air streams generally, and the tangential components thereof in particular, are substantially well-behaved for the purpose of generating the desired air curtain. That is, the air stream has vertical velocity vectors much greater than the corresponding horizontal vectors directed towards the left wall of the oven and hence it has been found that, for the dimensions of a conventional domestic oven chamber, two left-hand vanes 19 will produce the desired effect. Whilst the two vanes are shown to be parallel, at approximately 15° inclination to the vertical, and extending beyond the top edge of the baffle by a factor of about $0.4\,\ell$ where ℓ is the length of the vanes 19, these parameters may be varied by relatively small amounts without departing from the inventive concept. In as much as the left-hand vanes 19 urge the air stream towards the left side wall, the right-hand vanes urge the air stream substantially in a vertical direction. That is, the substantial velocity vector component of the air stream being interrupted by the four vanes is slightly vertical of horizontal. Thus, to minimise vorticity effects and multiple eddies in the right-hand area of the cavity behind the baffle, more and outwardly inclined vanes are required. Again these vanes are shown as being equally spaced mutually, of length ℓ of inclination 15° to the vertical, and extending $0.4\,\ell$ beyond the top edge of the baffle. These parameters have also been chosen as representing the optimal effect conductive with ease and cost of manufacture of the completed baffle, but they may be

similarly varied, both individually and mutually, within the inventive concept. In particular, as few as three vanes may suffice and, in some applications five or six may be desirable.

The lower edge of baffle 13 may also be provided with a series of vanes such that, as illustrated with the top of the baffle, there are four outwardly directed vanes on the left side and two on the right. This arrangement may be visualised by taking Cartesion axes through the centre of grid 14 and rabatting the plane of the baffle once only about each of the ordinate and abcissa.

However an arrangement of dampers or vanes 20 and louvres 21 is preferred. For a number of reasons not yet fully understood but including at least the fact that the bottom of the foodstuff to be baked presents a flat surface parallel to the bottom wall of the oven (e.g. a cake tin or a roasting dish), the preferred arrangement produces a somewhat improved result over that of the above described series of vanes 19.

On the left side of the lower edge, two vanes 20 are shown which are effectively intended to be positioned mirror images of the upper pair. Next to this pair and slightly off-centre on the left side of centre is shown a die punched louvre 21 opening into the rear space. This louvre acts as an air scoop and thereby redirects most of the vertically-downward component of the air stream vector in the lower central region of the baffle. A further director vane 20 is positioned adjacent the single louvre 21 and is identically parametered with respect to the lower edge of the baffle as vanes 19 are to the upper edge. Centrally disposed between the single baffle 20 and the right-hand wall of the oven are a pair of duplexed louvres, similarly die punched in the rearward direction. All three louvres fall within the boundary defined by the linear extension of

the inner ends of vanes 20 and the lower edge of the baffle.

It will be appreciated that the vanes 19 and 20 may extend rearwardly at right angles to the baffle in close proximity to the rear wall, or in contact with the rear wall and secured thereto (if required). For manufacturing purposes or otherwise, vanes 19 and 20 may alternatively be positioned on the rear wall of the oven in lieu of being on the baffle plate 13. In this arrangement the baffle plate 13 may no longer require mounting brackets 6 and may in lieu thereof be mounted on the vanes 19 and 20. Accordingly all references in this specification to the baffle plate and the vanes are deemed not to exclude this alternative arrangement. Similarly references to the vanes being in proximity to the rear wall of the oven deemed to include an arrangement whereby the vanes are positioned on the rear wall in such a fashion as to be slightly spaced from the surface of the rear walls. Similarly the upper and lower limits of the top and bottom vanes respectively are in close proximity to the top and bottom walls of the oven chamber. It should also be appreciated that no air flows around the sides of the baffle since these are close or secured to the side walls of the chamber, but it is deemed within the scope of this invention to provide a spaced relation between each side of the baffle and its corresponding chamber wall. In such an arrangement a plurality of upwardly and downwardly-directed vanes would be located on the rear side of the baffle 13 in like fashion to the arrangement described above. However, it is postulated that a more effective air curtain results when only the top and bottom of the baffle enable air streams to enter the oven chamber, the flow characteristics thereof being modified in accordance with the invention.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A forced air oven comprising an oven chamber, an air circulating fan mounted within said chamber on a drive shaft extending through one wall of the chamber, heating means mounted within the air stream generated by said fan, a baffle plate mounted in front of the fan in paralleled spaced relation with said one wall, a centrally disposed aperture in said baffle plate to enable air from the chamber to be drawn through the baffle plate by the fan into the region defined by said paralleled spaced relation, a plurality of left-hand and right-hand vanes located on the fan side of the baffle plate in the vicinity of both the top and bottom edges thereof, said plurality of vanes extending across said region in proximity to said one wall and extending beyond both of said top and bottom edges in proximity to the top and bottom walls of said chamber respectively, said left-hand vanes being fewer in number than said right-hand vanes, said left-hand and right-hand vanes subtending acute angles to the vertical such that said air stream substantially exhibits an air curtain flow pattern in said chamber.

2. An oven as claimed in Claim 1 wherein the side edges of the baffle plate are in contact with the respective surfaces of the side walls of the chamber such that there is no air flow therebetween.

3. An oven as claimed in Claim 1 or 2 wherein each of said acute angles is x° and the angle subtended between any one or all of the left-hand vanes and any one or all of the right-hand vanes is $2x^{\circ}$.

4. An oven as claimed in Claim 1,2 or 3 wherein said heating means comprises a sheathed electric heating element helically formed in close proximity to the circumference of said fan.

5. An oven as claimed in any one of Claims 1 to 4

comprising a plurality of louvres formed in the surface of the baffle plate in said vicinity of the bottom edge of the baffle plate wherein said louvres are scooped beyond the rear surface of the baffle plate into said region.

6. An oven as claimed in Claim 5 wherein the formation of said louvres is substantially in both the median and right-hand sections of said vicinity of the bottom edge of the baffle plate.

7. An oven as claimed in any one of the preceding claims wherein said extending of the vanes beyond both top and bottom edges is approximately 0.4 times the length of the vanes.

8. An oven as claimed in any one of Claims 4 to 7 as appended directly or indirectly to Claim 3 wherein x is approximately 15^{o}.

9. An oven as claimed in Claim 6 or in Claim 7 or 8 as appended to Claim 6 wherein the number of said vanes is two, four, two and one respectively in the left-hand top edge, right-hand top edge, left-hand bottom edge and right-hand bottom edge, and the number of said louvres is one and two respectively in said median and right-hand sections.

10. A forced air oven substantially as herein described with reference to the accompanying drawings.

Dated this 10th day of November, 1978

EMAIL LIMITED

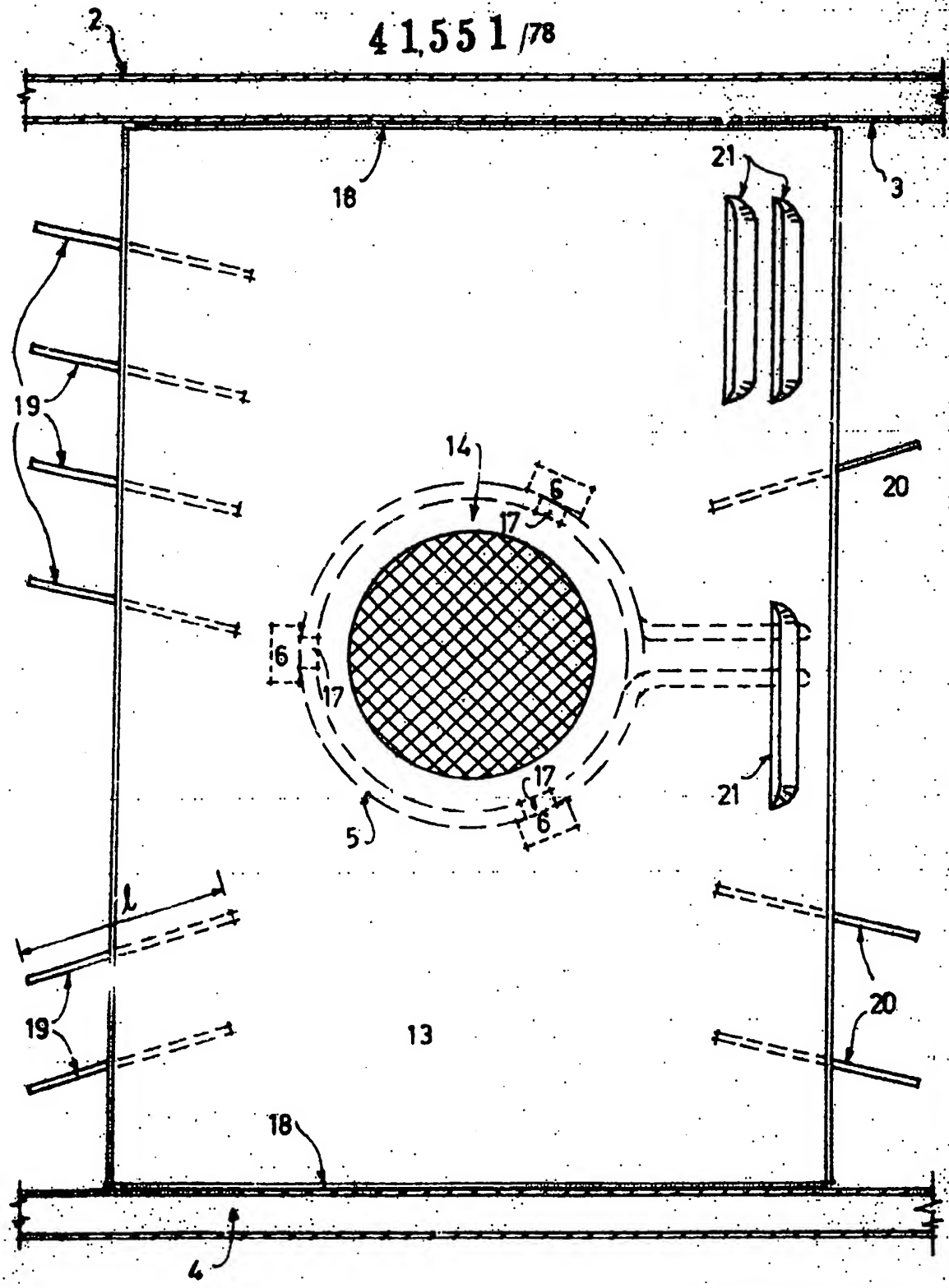

FIG. 2.

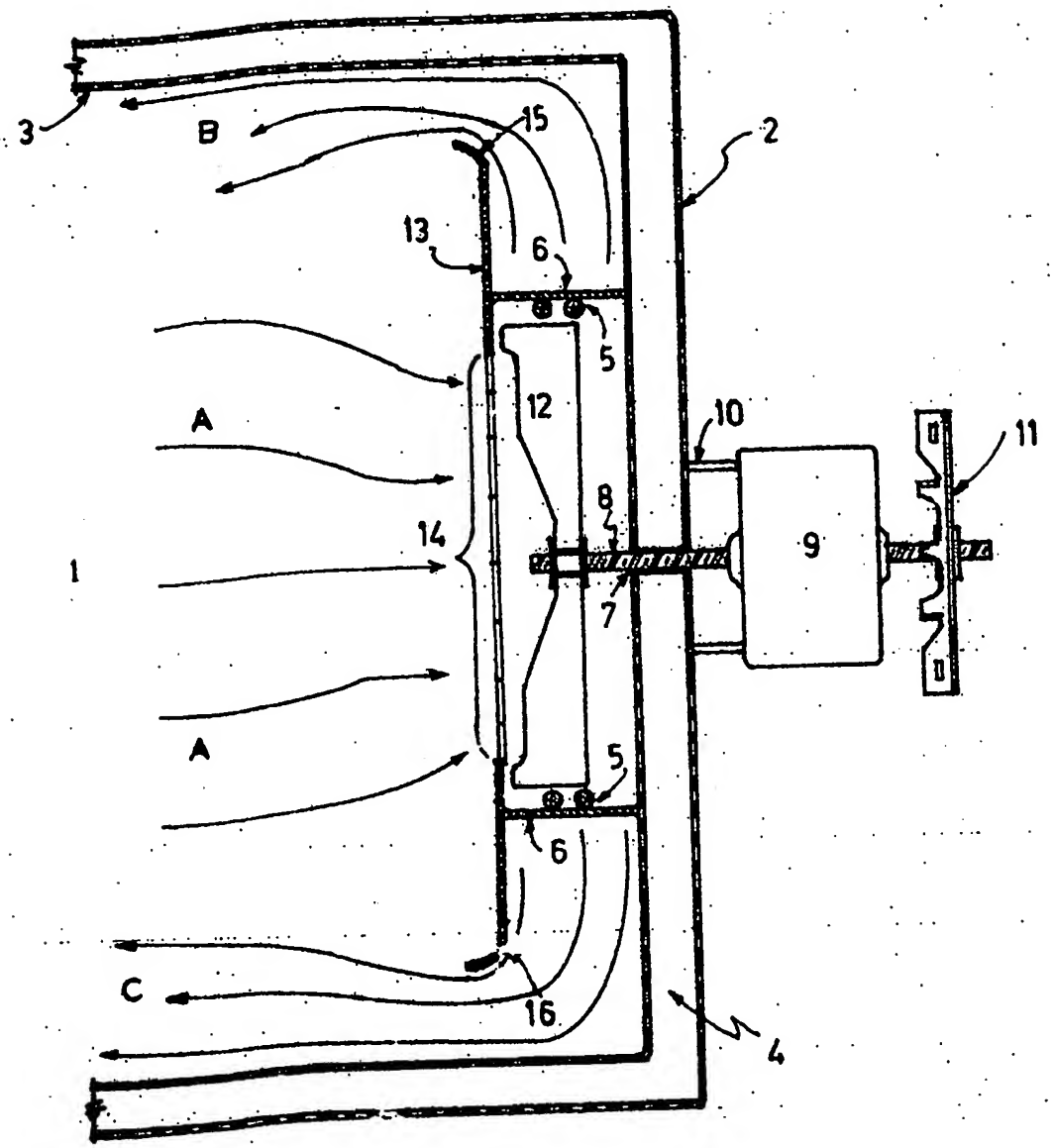

FIG. 1

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